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Full Length Research paper

Effect of tillage practices on soil physico-chemical characteristics and wheat straw yield

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Tillage practices affect physico-chemical characteristics of soils and straw yield. Therefore, a field study was conducted for two years (2012-2013 and 2013-2014) with four tillage practices i.e., happy seeder (HS), roto –tillage (RT), no-tillage (NT) and conventional tillage (CT). Effect of these treatments was observed on soil pH, electrical conductivity (EC), cation exchange capacity (CEC), soil organic carbon content (SOC), Av. N, P and K and straw yield of wheat in two soils i.e., sandy loam (SL) and loamy sand (LS) separately. Among tillage practices, the mean highest SOC was found under HS (3.44 g kg^{-1}) followed by RT (3.26 g kg^{-1}), NT (3.01 g kg^{-1}) and the lowest under CT (2.58 g kg^{-1}) for SL soil. Mean highest Av. N (kg ha^{-1}) was observed under HS (128.4) and the lowest under CT (102.6) for SL soil. Effect of tillage and residue management practices on soil pH, EC and CEC was not significant in both the soils. The mean highest straw yield (t ha^{-1}) in SL and LS soil was observed under HS (7.5 and 6.9) followed by RT (7.1 and 6.5), NT (6.8 and 6.2) and least under CT (6.3 and 5.8) in SL and LS soils respectively.

Key Words: Tillage, physico-chemical, organic carbon, straw yield, wheat.

INTRODUCTION

Tillage has been part of most agricultural systems throughout history because it achieves many agronomic objectives (e.g., seed bed preparation, soil conditioning, weed suppression and residue management). But, the excessive tillage practices adversely affect soil health, crop productivity and environment quality by affecting soil structure, soil carbon loss and emission of greenhouse gases (Beare *et al.,* 1994). On the other hand conservation tillage results in retention of more than 30 per cent of crop residue that helps in improving the overall soil quality, carbon sequestration and crop productivity (Tessier *et al.,* 1990). During the past few years, research efforts have been focused to reduce the cost of cultivation, increasing productivity and maintaining, rather improving the soil health. The technologies developed, tested and validated are Happy Seeder (HS), no-tillage (NT), conventional tillage (CT) and roto-tillage (RT). The direct drilling of wheat through HS offers the apparent advantage of timely planting, fuel and labour cost. It is a kind of no-tillage where succeeding crop is planted directly in the standing stubbles of the previous crop without seed bed preparation. The NT is another conservation tillage system that disturbs the soil surface to the minimum possible extent (Lal 2003). Tillage and crop residue management can play a significant role in improving soil quality, crop productivity and preventing environmental pollution (Iqbal *et al* 2005). Conservation tillage improves economic performance and energy efficiency and reduces production risks (Zentner *et al.,* 2002) it decrease soil disturbance, improve soil organic carbon(SOC), maintain and benefits soil quality (Zentner *et al.,* 2004).The area under NT has substantially increased in South Asia and particularly the Indo-Gangetic plains (Derpsch *et al.,* 2010). The NT technology decrease soil disturbance, improve soil organic carbon and benefits soil quality (Arshad *et al.,* 1990, Zentner *et al.,* 2004).

Tillage treatments and associated cropping systems cause variation in pH values of soils and significant difference was found between NT and CT treatments. The lowest value for pH was reported with NT treatment (Rahman *et al.,* 2008). So *et al.,* (2000) observed that tillage increased the mineralization of nitrogen through break down of organic matter which may increase crop yield in short-term but in longer term continuous tillage

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Table 1. Effect of tillage practices on soil pH, EC, soil organic carbon (SOC, g kg^{-1}) and CEC (cation exchange capacity, cmol kg^{-1} soil) in sandy loam (SL) and loamy sand (LS) soils.

Tillage practice	SL	LS	SL	LS	SL	LS	SL	LS
	Soil texture							
	pH		EC (dS m^{-1})		OC (g kg^{-1})		CEC (cmol kg^{-1} soil)	
HS	7.02	7.11	0.17	0.14	3.44	3.12	6.08	5.85
RT	7.12	7.23	0.21	0.17	3.26	2.77	5.86	5.62
NT	7.19	7.34	0.24	0.21	3.01	2.41	5.76	5.43
CT	7.27	7.43	0.27	0.23	2.58	2.22	5.53	5.36
Mean	7.15	7.27	0.22	0.18	3.07	2.63	5.81	5.56
LSD (P<0.05)	NS	NS	NS	NS	0.66	0.34	NS	NS

degrades soil organic matter and reduces soil fertility and structural stability. The surface soil beneath the canopy had higher OM content in both tillage systems, particularly under NT. Moussa-Machraoui *et al.,* (2010) studied that the contents of SOC was slightly greater under NT than under CT. NT increases soil C stock by an average of 4-7 per cent. The enhancement of SOC and SOM contents in the soil under NT is often accompanied by the enhancement of the cation exchange capacity (CEC). Wang *et al.,* (2008) after their 16 years study reported that continuous long-term conservation tillage practice (NT, straw cover) significantly increased SOM, total N and available P in the surface soil (0 to 10 cm) layer. Many studies have reported lower SOC and water-stable aggregates content in CT when compared to NT (Beare *et al.,* 1994 and Six *et al.,* 1999). Bricchi *et al.,* (2004) observed that the SOC was significantly higher when stubble was left on surface. Under conservation tillage the organic carbon increased by 11 per cent as compared to CT after 5 years. Liang *et al.,* (2007) demonstrated that NT significantly increased the concentration of SOC by 5.6-5.9 per cent on the clay loam soils after 3 years in the humid northeastern China. Hazarika *et al., (*2009) observed 14-17 per cent higher SOC in surface layer under NT than CT, while a reverse trend was observed in the lower depths. Tillage operations and soil disturbance generally cause an increase in soil aeration, residue decomposition; Organic N mineralization and availability of N for plant use (Dinnes *et al.,* 2002). Moussa-Machraoui *et al.,* (2010) observed that some of the chemical parameters of soil were significantly modified under NT when compared to CT system. The nutrient (N, P, K, P_2O_5 and K_2O) contents were more under NT than CT.

Gangwar *et al.,* (2006) reported no changes in soil available P and K due to tillage practices. But residue incorporation increased SOC and available P while higher available K was monitored in burning treatment. Long-term NT management commonly leads to a stratification of available P in soils (Zibilske *et al.,* 2002). The surface soil accumulation of P in conservation tillage was attributed to the limited downward movement of particle bound P in soils and the upward movement of nutrients from deeper layers through nutrient uptake by roots (Urioste *et al.,* 2006 and Wang *et al.,* 2008). Matowo *et al.,* (1999) reported that after 10 years the extractable P was significantly greater in NT compared with chisel till in the 5 cm layer, while extractable K was not influenced by tillage treatments. Keeping above facts in view, the present investigation was undertaken with the objectives to study the effect of conservation tillage and residue management practices on soil physico-chemical characteristics and wheat straw yield in sandy loam and loamy sand soils.

MATERIAL AND METHODS

A study was conducted on tillage practices at research farm of Department of Soil Science, Punjab Agricultural University, Ludhiana (30° 56’ N latitude and 75° 52’ E longitude) in sandy loam (SL) and loamy sand (LS) soils separately. The experiment involved wheat sowing by four tillage systems {HS (Happy seeder: surface rice residue retention and sowing of wheat by HS machine), RT (Roto- tillage: rice residue incorporation into the soil by two rotavator operations and sowing by ordinary drill), NT (No-tillage: residue removal and sowing by no-till machine), and CT (Conventional tillage: disking followed by cultivator and one planking operation)}. Plots were 11 m long and 3 m wide. The mean maximum and minimum temperature of the study site showed considerable fluctuations during different parts of the year. Summer temperature reaches up to 45°C, while winter experiences frequent frosty spells especially in December and January and minimum temperature dips up to 0.5°C. The average annual rainfall of studied location was 733 mm and the major portion of which (75%) is received during July to September. Soil pH was determined (1:2 soil: water suspension) using a pH meter fitted with a calomel glass electrode (Model Elico LI 127). EC of 1:2 soil: water supernatant (kept overnight) was estimated using a solubridge (model Systronic Conductivity Meter 304). Oxidizable soil organic

Table 2. Effect of tillage practices on available N, P and K in sandy loam (SL) and loamy sand (LS) soils.

	Soil texture					
Tillage practice	**SL**	**LS**	**SL**	**LS**	**SL**	**LS**
	Available N (kg ha^{-1})		**Available P (kg ha^{-1})**		**Available K (kg ha^{-1})**	
HS	128.4	115.5	68.4	55.8	166.2	146.6
RT	122.3	108.6	66.5	52.3	147.7	140.3
NT	116.7	102.7	58.1	49.7	140.6	133.2
CT	102.6	98.5	52.6	41.4	136.4	128.4
Mean	117.5	106.3	61.4	49.8	147.7	137.1
LSD (P<0.05)	7.2	6.3	NS	NS	NS	NS

carbon was estimated using (Walkley and Black 1934) rapid titration method, using a diphenyl amine indicator. Alkaline $KMnO_4$ (potassium permanganate) method as described by Subbiah and Asija (1956) was used to determine available nitrogen in soil samples. Available phosphorus was determined by extracting the soil samples with 0.5 M $NaHCO_3$, pH 8.5 (Olsen *et al.,* 1954) and measuring the P content in the extract by colorimetric method using a spectrophotometer at 760 nm wavelength using ascorbic acid method. Available potassium content in soil was estimated by extraction of soil with neutral 1N NH_4OAc solution of potassium in the extract was determined using flame photometer as described by Page *et al.,* (1982). Normal sodium acetate (NaOAc) (pH 8.2) was used to determine the CEC of the soils following the procedure of Bache (1976).

RESULTS AND DISCUSSION

Soil pH

Effect of tillage practices on soil pH was not significant in both SL and LS soils (Table 1). However, among the tillage practices, the mean highest pH was found under CT (7.27) followed by NT (7.19), RT (7.12) and the lowest under HS (7.02) for SL soil. Similarly, for LS soil, the mean highest pH was observed under CT (7.43), followed by NT (7.34), RT (7.23) and lowest under HS (7.11) practices. Rahman *et al.,* (2008) also observed no significant differences in soil pH among NT and CT practices. Tarkalson *et al.,* (2006) reported 9 per cent decrease in soil pH under NT as compared to CT due to enhancement of acidification.

Electrical conductivity (EC)

The data pertaining to EC as affected by tillage practices under SL and LS soil is presented in Table 1. The mean highest EC was found under CT (0.27 dS m^{-1}) followed by NT (0.24 dS m^{-1}), RT (0.21 dS m^{-1}) and lowest under HS (0.17 dS m^{-1}) for SL soil. Similarly, in LS soil, the mean highest EC was observed under CT (0.23 dS m^{-1}), followed by NT (0.21 dS m^{-1}), RT (0.17 dS m^{-1}) and lowest under HS (0.14 dS m^{-1}). Patni *et al.,* (1998) also reported decrease in soil EC under NT which might be due to more downward movement of salts along with water infiltration into deeper layers.

Soil organic carbon (SOC)

The data pertaining to SOC, as affected by tillage and residue management practices is presented in Table 1. The SOC was observed to be significantly affected by tillage practices in both SL and LS soils. The mean highest SOC was found under HS (3.44 g kg^{-1}) followed by RT (3.26 g kg^{-1}), NT (3.01 g kg^{-1}) and the lowest under CT (2.58 g kg^{-1}) for SL soil. Similarly, for LS soil, the mean highest SOC was observed under HS (3.12 g kg^{-1}), followed by RT (2.77 g kg^{-1}), NT (2.41 g kg^{-1}) and lowest under CT (2.22 g kg^{-1}) practices. HS and NT reduces soil disturbance, improve SOC maintenance and benefits soil quality (Zentner *et al.,* 2004; Bhattacharyya *et al.,* 2006). Hazarika *et al.,* (2009) reported 14-17 per cent higher SOC in surface soil under NT and RT than CT practices.

Cation exchange capacity (CEC)

The effect of tillage practices on CEC was statistically at par for both soils (Table 1). Numerically, among the tillage practices, the mean highest CEC (cmol kg^{-1} soil) was found under HS (6.08) followed by RT (5.86), NT (5.76) and the lowest under CT (5.53) for SL soil. Similarly, in LS soil, the mean highest CEC (cmol kg^{-1} soil) was observed under HS (5.85), followed by RT (5.62), NT (5.43) and lowest under CT (5.36) practices, respectively. Soil surface accumulation of organic has been reported to increase CEC under NT as compared to CT (Karathanasis and Wells 1989 and David *et al* 2006).Tarkal-

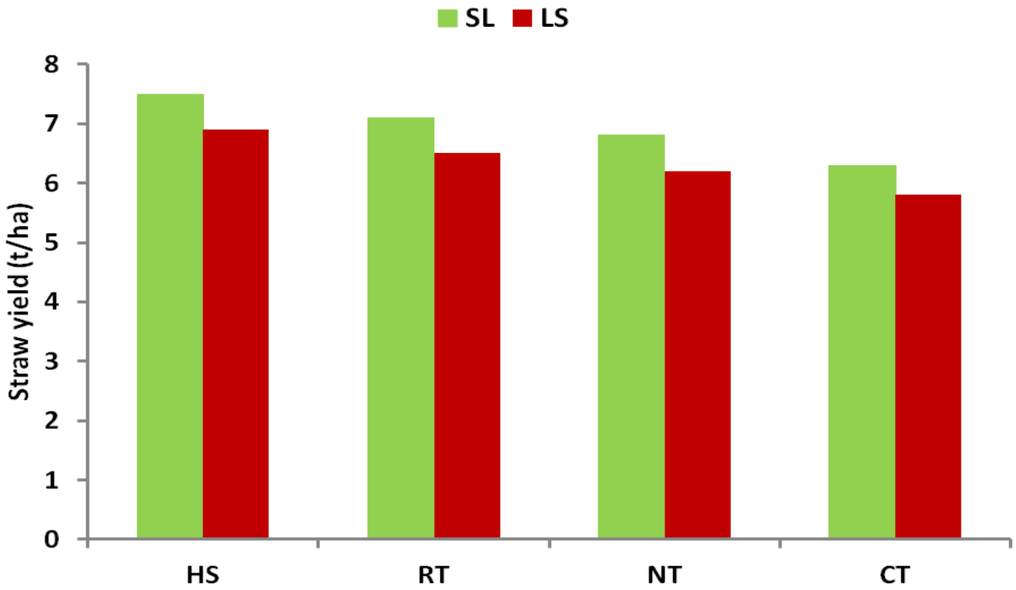

Figure 1. Effect of tillage practices on wheat straw yield under sandy loam (SL) and loamy sand (LS) soils.

son *et al* (2006) reported more CEC under NT due to increased potential of conserving plant nutrients.

Available nitrogen (Av. N)

The Av. N as affected by tillage practices under SL and LS soil is depicted in Table 2. Tillage practices significantly affected Av. N. The mean highest Av. N (kg ha^{-1}) was observed under HS (128.4) followed by RT (122.3), NT (116.7) and the lowest under CT (102.6) for SL soil. Whereas, in LS soil, the mean highest Av. N (kg ha^{-1}) was observed under HS (115.5) followed by RT (108.6), NT (102.7) and lowest under CT (98.5) practices, respectively. Arshad *et al* (1990) found that Av. N content of surface soil was 25% higher under NT than CT plots. Moussa-Machraoui *et al* (2010) also reported more Av. N under NT due to more organic matter accumulation.

Available phosphorus (Av. P)

Tillage and residue management practices had no significant effect on Av. P in both textured soils (Table 2). Numerically, among the tillage practices, the mean highest Av. P was found under HS (68.4 kg ha^{-1}) followed by RT (66.5 kg ha^{-1}), NT (58.1 kg ha^{-1}) and the lowest under CT (52.6 kg ha^{-1}) for SL soil. Whereas, LS soil, the mean highest Av. P were observed under HS (55.8 kg ha^{-1}), followed by RT (52.3kg ha^{-1}), NT (49.7 kg ha^{-1}) and lowest under CT (41.4 kg ha^{-1}) practices, respectively. NT results in surface accumulation of phosphorus by contributing to increased P availability through release of inorganic P from decaying residues (Palm *et al* 2001).

Available potassium (Av. K)

The effect of tillage practices on Av. K was statistically at par for both SL and LS soils (Table 2). Numerically, among the tillage practices, the mean highest Av. K (kg ha^{-1}) was found under HS (166.2) followed by RT (147.7), NT (140.6) and the lowest under CT (136.4) in SL soil. Similarly, in LS soil, the mean highest Av. K (kg ha^{-1}) was observed under HS (146.6) followed by RT (140.3), NT (133.2) and lowest under CT (128.4) practice, respectively. Increased Av. K in untilled soil was correlated with increased organic matter content (Karathanasis and Wells 1989). Franzluebbers and Hons (1996) also reported that soil managed by NT had greater available K concentrations in the surface soil layer than with CT.

Straw yield

Straw yield as affected by tillage practices under SL and LS soils is presented in Figure. 1. The effect of tillage practices on straw yield was non-significant for the both soils. The mean highest straw yield (t ha^{-1}) in SL and LS soil was observed under HS (7.5 and 6.9), followed by RT (7.1 and 6.5), NT (6.8 and 6.2) and least under CT (6.3 and 5.8). The reason for higher straw yield in HS was effective utilization of the water and nutrients by plants under the HS than that of other tillage practices (Imran *et al* 2013).

It is thus, concluded from the study that conservation tillage practice i.e. Happy Seeder (no tillage with residue retention) enhances soil organic carbon content and wheat straw yield.

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